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DATA SURVEY AND ANALYSIS

ENGINEERING DATA STORAGE AND RETRIEVAL PROJECT

FINAL REPORT

for the period May 1969 to October 1970

by

J. B. Malcom

J. M. Watson

H. S. Firey

October 1970

prepared for

PICATINNY ARSENAL

Dover, New Jersey 07801

Under Contract DAAA21-69-C-0642

by

DATAFLOW SYSTEMS INCORPORATED

7758 Wisconsin Avenue

Bethesda, Maryland 20014

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ABSTRACT

The Data Survey and Analysis task, under the Engineering Data Storage and Retrieval (EDS&R) Project, screens, selects, gathers, analyzes and develops information related to the storage and retrieval of engineering data. These activities, directed toward defining current, new and future systems of engineering data storage and retrieval, have produced a series of publications and reports, including a Master Index to Engineering Data Files in 16mm Microfilm Format, a monthly engineering data systems review, and a series of twelve technical notes covering specific investigations of equipments (AMACUS, GESCAN, UNICON, DSI 400), of techniques (converting file structures to binary coded microfilm), of programs (the DOD Engineering Data Systems), and of definitions and scope of the EDS&R Project. Conclusions and recommendations are presented.

TABLE OF CONTENTS

TABLE OF CONTENTS
(cont'd)

1.0 Introduction and Summary

The Engineering Data Storage and Retrieval (EDS&R) Project is an exploratory development project to define microfilm storage and retrieval systems usable throughout the U.S. Army by engineering personnel. The initial system concept is microfilm oriented. It provides the means of storing a wide variety of engineering data from diverse sources, permitting exchange of engineering data between agencies. Additional techniques and applications are also used and evaluated. Future aspects of the Project recognize the potential of data processing systems to acquire or process data for conversion to microforms, and also the use of communication techniques in engineering data exchange activities.

The Advanced System Concept and the Long Range System Concept of the EDS&R Project concern the systems expected to evolve from the present development project. The first uses existing equipments and procedures for EDS&R, and the later is based upon equipment and procedures not currently within the state-of-the-art, but potentially adaptable to the EDS&R Project.

These three aspects of the EDS&R Project, that of the present systems, new systems, and future systems, require a constant awareness of equipments, systems, methods and techniques. Specific information must be gathered in selected areas, summarized and presented. The data survey and analysis effort is directed toward this and.

A previous effort by Dataflow Systems Inc. identified various collections of engineering data and information held in microfilm formats, and recommended development of a "Master Index" to encourage the exchange of these collections. The concept of a Master Index is an accepted part of the EDS&R Project, and this contract has produced such an index for engineering data files in 16mm microfilm formats.

The larger objective of this contract, however, has been to establish the techniques, methods, and systems necessary for all aspects of the EDS&R concept. To accomplish this, a constant survey and analysis has been made of the existing, evolving,and future technology relating to engineering data storage and retrieval.

These efforts, under the direction of the Contract Project Officer, have produced a series of Technical Notes summarizing various efforts:

- Definitions are always critical to a clear understanding. Existing definitions were gathered and summarized in Technical Note 1, and, in Technical Note 2, the scope and interest of the EDS&R Project was defined with respect to these definitions as "bench engineering information".

- The first commercial unit to incorporate a time-shared computer directly with 16mm microfilm was the DSI Microsearch 400 unit. Technical Note 3 investigated the approach.

- Ultrafiche, a high-reduction-ratio sheet microfilm, offers great compacting of data, and, at about one dollar per ultrafiche with up to 3000 pages, offers some unusual economics. Technical Note 4 surveyed the use of ultrafiche and its application to EDS&R systems.

- Technical Note 5 reviews the UNICON, a laser mass-memory device with a trillion-bit capacity.

- The AMACUS combines data processing and microfilm technology to modify existing aperture cards. The AMACUS and its application to EDS&R is discussed in Technical Note 6.

- Computer-Output-Microfilm (COM) technology has great impact on the engineering data field. These aspects and significant COM equipment are surveyed and analyzed in Technical Note 7, and summarized in Technical Note 8.

- The Engineering Data Systems program, under the DOD Standardization Program, has produced little documentation for distribution via the Defense Documentation Center. Technical Note 9 (in draft only) summarized the Engineering Data Systems Program based on available information.

- Facsimile equipment, offering a new communication link between a central data bank and the user, was surveyed and summarized in Technical Note 10.

- A specialized data storage and retrieval device, the General Electric's GESCAN system, was reviewed in Technical Note 11.

- Methods and techniques for converting existing engineering files to binary coded microfilm were developed in Technical Note 12, with special emphasis on the files, format, indexing structure, and physical arrangement.

In the course of contract performance and other professional activities, many items related directly and indirectly to EDS&R came to our attention. With some additional effort, they have been summarized and published monthly in a "Monthly Review".

Other conclusions and recommendations note the need for continued leadership in the area by the EDS&R Project. The need for analysis of current, new, and future applications of information technology to engineering data continues, and the EDS&R Project should actively participate at all feasible levels. Communication between the users and producers of engineering data technology must be increased through seminars, presentations, applications notes, and the trade literature. Methods and standards for system evaluation are needed. New application should look at new technology areas, and in particular, new applications of EDS&R using small computers and computer-output-microfilm should be given attention.

Much of the effort of this contract has been reported in the technical notes, the presentations, and the EDS&R Monthly Review. The report which follows summarizes these efforts for the period from May 1969 to October 1970. Some additional items are currently in progress, such as the listing of the DOD facsimile stations and equipments, and a survey of standard microfilm containers, and although not completed, have been reported informally and via the monthly progress reports to the Contract Project Officer.

2.0 General Discussion

2.1 The EDS&R Project

The Engineering Data Storage and Retrieval Project, under the direction of the Commanding Officer, Picatinny Arsenal, and sponsored by the Chief of Army Research and Development, Information Systems Office, Army Research Office, is a research and development project aimed at developing better utilization of existing engineering data and information. The EDS&R philosophy is that:

- o Nothing is invented
- o No data is created
- o Utilization is made of existing hardware, data, data media and procedures
- o Applications reflect genuine problems
- o EDS&R applications must be recommended by the user, not by the systems design people

Within this context, the EDS&R program is directed toward the storage, retrieval, and exchange engineering data and information. The terms "data" and "information" are used in the broader sense since the philosophy is concerned with the media of storage and exchange more than with the technical nature of the data or information.

2.2 Aims and Objectives of Data Survey and Analysis Effort

The primary thrust of the Dataflow Systems' effort has been to identify, analyze, and recommend utilization of existing techniques, methods, equipments, and data collections related to the EDS&R Project. To accomplish this, a continuous survey has been made of the information systems field, selecting specific items for further analysis and comment.

The secondary objective, almost inherent to the first, is to relate the EDS&R concept to the real world. This has required the identification, collection and analysis of the factors and forces that bear on the field of engineering information handling, both present and in the future. This objective provides the basis for evaluating current activities within the EDS&R Project, and planning future programs. The area of computer output microfilm is an excellent example of this activity.

2.3 Discussion of the Data Collection Techniques

A key aspect of the data survey and analysis effort has been to provide a current awareness function for the EDS&R Project. The involvement of Dataflow System in other active areas of information services, such as professional seminars and market analysis, has complemented the continuous review of current literature for items significant to the project. These items were followed-up by personal interviews where possible, correspondence, telephone conversations, and presentations by industry representatives. Further literature searching often provided additional background material.

In other cases, such as for the Master Index and for the microfilm container study, mail and telephone survey questionnaires were utilized. Generally speaking, a combination of techniques most economical of achieving the end objective were followed.

2.4 Delivery and Presentation of Materials

Technical Notes

As specific efforts were completed during the course of this contract, the methodology used, the analysis made, and the results and recommendations were presented as technical notes. A total of 12 technical notes were delivered, ranging from several pages in length to fairly major efforts, such as the computer output microfilm technical note, which covered 72 pages. The majority of these technical notes were further distributed by the EDS&R Project Office as interim reports. These notes are individually discussed in Section 4.

The Master Index

The Master Index to engineering data files in 16mm microfilm formats was produced in both microfilm and hard copy formats. The 16mm binary coded microfilm version was primarily an evaluation effort with limited distribution to the EDS&R Project Officer and to the Engineering Data Systems Office at the Army Missile Command at Huntsville, Alabama. The paper copy version, derived from a reformatting of the microfilm camera copy, is available through the Defense Documentation Center and the Clearinghouse for Federal Scientific and Technical Information. Manual index listings were produced and added to the paper copy edition.

Presentations

Various presentations were made of different technical aspects during the course of the contract. The definitions developed in Technical Note 1, EDS&R Data Definitions, were presented and discussed with personnel from engineering, standardization, and configuration management functions at Picatinny Arsenal. The Master Index, in a binary coded 16mm microfilm version, was presented at the Army Missile Command, Huntsville, Alabama, and at Picatinny Arsenal. The Computer Output Microfilm Technical Note was also presented at Picatinny Arsenal. In accordance with the contract, 50 copies of the book version of the Master Index were delivered, without format presentation, however, since close liaison had been maintained.

EDS&R Monthly Review

To meet the requirement for keeping the EDS&R task team informed on new developments in equipment and technology relevant to the project, the "Monthly Review: EDS&R Technical Notes From Current Literature" was initiated. This newsletter briefly reviews new equipment just entering the market, new techniques using old equipment in different applications, research and development projects that may lead to new technological advances in the future, announcements of significant association meetings, seminars or presentations, and citations of recent publications or articles relevant to the project.

The EDS&R Monthly Review has proved to be quite popular, and is redistributed as an "interim report" by the EDS&R Project. A total of 15 monthly newsletters were produced, covering a dozen or so different items each month.

Material is gathered by reviewing trade journals, from discussion, conversations, and personal correspondence with the profession, and visits to libraries for literature research.

2.5 Recognition of the EDS&R Concept

During the course of contract performance, some 16 months, many different activities within the field of information technology were contacted. Support and cooperation was sought by explaining the EDS&R concept and the contractual relationship of DfS in gathering relative information. In most cases, this cooperation was freely and readily given, and DfS is indebted to these organizations and people. Other scatter cases, however, failed to respond and appropriate follow-up was necessary. Never-the-less, the widespread contact of the DfS effort with activities external to the Army has created an awareness of the Project which should make future contacts progressively more responsive.

3.0 The Master Index

Master Index to Engineering Data Files in Sixteen Millimeter Microfilm Formats First edition. Dataflow Systems Inc. September, 1970.

The need for a "Master Index" to identify and describe available engineering data files was one of the conclusions of a previous effort (see: Nuclear Weapons Engineering Data System (NWEDS) Data Base Expansion. Final Report. Dataflow Systems Inc., March, 1969). While the report identified and described relevant data files, it was evident that additional effort would be needed if an effective guide for the interchange of engineering data within the DOD were to be developed.

This concept of a Master Index to encourage the interchange of engineering data microfilm files was incorporated into the EDS&R Project as a basic item, and the first paper copy edition was published under this contract in September, 1970. The Project is vitally concerned with the problem of duplication of effort in the use and re-use of engineering data. The development of the Master Index concept, then, is one method to avoid costly and time-consuming duplication of engineering efforts at one location that have already been accomplished at another.

The initial identifying procedures had established that these engineering data files would be roll or cartridge 16mm microfilm to take advantage of the ease of duplication and transfer of data on microfilm. Letters and telephone queries were made to all originators of known files, requesting that the information previously collected be updated, and index terms suggested. The descriptions were revised accordingly, and indexed using standard vocabulary terms from the "Thesaurus of Engineering and Scientific Terms" whenever possible, and adding terms as required.

In November, 1969, a test project was initiated that produced a limited number of cartridges of the Master Index on binary-coded 16mm microfilm. This test film was distributed to selected users for evaluation and testing. The film was produced using the Eastman Kodak MIRACODE system. A comprehensive "Users Manual" was published to accompany the MIRACODE cartridge and included detailed explanations of the special binary coding and instructions on how to retrieve information on engineering data files from microfilm.

For the first edition of the Master Index in a document format, all previous file descriptions were again informally updated. The indexing and instructions were revised for manual searching.

The Master Index provides a consolidated reference to scientific and technical data useful in the engineering environment and available in 16mm microfilm formats. Users desiring specific information can determine if such information is within the scope of the indexed files, where the file is located, and how it can be obtained.

Forty-five commercial and Federal engineering data files are included in the first edition, arranged alphabetically by file title. The individual files are indexed by producing activity and, more importantly, by subject description. The following information is provided by each file description:

File size and type
Arrangement of information and type of index
Security classification
File availability, mailing address and distribution source, and restrictions, and costs
Number of reels (cartridges)
Period covered, updating cycle
General subject content
Index terms
Local availability

A list of obsolete files is provided for those users who received the test project index in the microfilm format. To encourage the addition of new files and the updating of current ones, forms and instructions are included to facilitate updating.

The contract requires that the Master Index be distributed to the Defense Documentation Center (DDC). The Technical Abstract Bulletin (TAB), issued by DDC, and the U.S. Government Research and Development Reports (USGRDR), the announcement service of the Department of Commerce's Clearinghouse for Federal Scientific and Technical Information (CFSTI) will announce the Master Index and should help greatly to introduce the Master Index to both the engineers and information specialists. Widespread announcement should also encourage the identification and listing of new files. The Master Index will probably be updated and reissued on a regular schedule by the EDS&R Project.

Consideration was given to future expansion of the Master Index concept to include other programs and resources of engineering data and information. These aspects can easily be incorporated into both book and microfilm versions, requiring only proper design of the indexing structure and file arrangement. Future evolution of the EDS&R Project may take this course, particularly if the present Master Index develops interest in such an undertaking.

4.0 Discussion of Technical Notes

Each of the technical notes prepared in the course of contract are discussed, including comments on the methodology not necessarily covered in the technical note itself. Requests for copies of the respective technical notes should be addressed to the Commanding Officer, Picatinny Arsenal, Attn:Code SMUPA-RT-E, Dover, New Jersey. The following technical notes are summarized:

4.1 Technical Note No. 1

EDS&R Data Definitions

"Engineering data" can mean many things to many people. The term "technical data" is a broader term and both terms are loosely used, interchanged, and confused. The EDS&R Project, using the term engineering data in its title, suffers from this confusion. The term "data" and "information" are likewise confusing, often interchanged, and usually dependent more on the context of their use than upon absolute definition. A better understanding of the EDS&R Project results if the term "engineering data" is more clearly set apart from the other definitions of data and information used in other contexts. The concept of data, as used in the EDS&R Project, must be defined in terms related to the EDS&R Project's use.

This technical note explored the meaning of the phrase "engineering data" as used in the EDS&R title. It noted that the systems concept was based on three elements for the data collections to be stored:

1. They are microform, i.e., they may be visually perceived
2. They are usable throughout the Army
3. They are used by engineers and technicians engaged in related efforts.

The key thought is to provide data and information of use to the true engineering function and not necessarily inherent to the logistics or procurement functions.

The various definitions of engineering data and information utilized in the various Department of Defense instructions and Army regulations were investigated. The relationships between these definitions, and the needs and intent of the EDS&R Project were noted. In particular, meaning of the broader term "technical data" in data management directives and in configuration management was discussed.

Each directive, regulation, and instruction defines terms for its own prupose. These definitions are summarized and include:

Data (AR 70-45)
Information (AR 70-45)
Engineering Data (DOD INST 5010.17)
Engineering Information
Technical Data (DOD INST 5010.12)
Technical Information (DOD Glossary RTD-2)
Scientific Information (DOD Glossary RTD-2)
Scientific and Technical Information (AR 70-45)

The note concludes that the standard accepted terminology is adequate to define the types of data, but the collective sources utilized by EDS&R Project cannot be defined except by a functional concept of input to the engineering task. For purposes of this program, this input is collectively called bench engineering information, and is defined:

Bench Engineering Information is information and data used by the engineer as source or reference material relative to his engineering task.

4.2 Technical Note No. 2

EDS&R Standardization Guide; Scope of Interest and Definitions

The definitions developed in Technical Note No. 1 were utilized as the basis for this technical note, formally presenting the EDS&R scope of interest and the definitions required for describing the project.

In particular, it noted the common characteristic of all EDS&R data and information as existing engineering data and information, produced by some previous technical effort, and of potential use or value to an engineer as input to his engineering task.

The technical note reiterated the definitions developed in Technical Note No. 1, and discussed the use of data and information in related areas. The flow chart illustrating the scope of EDS&R interests was developed.

4.3 Technical Note No. 3

Applications of The DSI Microsearch 400 System

The DSI Microsearch 400 system combined the existing technologies of cartridge microfilm storage and retrieval and computer time-sharing. At this time the systems are not being marketed as originally designed, and future developments are uncertain. The basic systems concept, however, is sound and still has many possibilities. The Microsearch 400 system consisted of a DSI designed and manufactured combination computer terminal and automatic cassette microfilm reader interface, through an acoustic coupler, with a time-sharing computer operated by DSI.

The unique system features allowed the user to create indexes to roll microfilm, to use COM generated roll microfilm with COM generated indexes and have the computer store and retrieve from these indexes and then automatically search the proper microfilm cassette for the correct images. DSI also provided COM services to produce fully indexed data bases on 16mm microfilm from a customer's data files. The microfilm was stored in DSI manufactured cassettes and the computer instructed film movement in the cassette to the correct frame.

DSI manufacturing facilities' were visited in Rockville, Maryland, by DfS personnel. The manufacturing of their own computer terminal and microfilm reader, rather than adapting proven off the shelf items, may have been a contributing factor to their financial troubles. The local facilities have been closed and a newspaper report states that DSI may market their systems in conjunction with a Honeywell mini-computer. The microfilm reader would be produced by another company and DSI would concentrate on marketing the systems.

Several important features of the DSI Microsearch system warrant review; indeed, other companies, such as 3M, are currently developing systems along similar lines and utilizing similar ideas. A strong feature of the DSI approach was the ability to create the microfilm data base using COM techniques. Special software packages enabled DSI to simultaneously produce indexes and microfilm through the COM process. This obviously saved the time involved in creating a separate index and assumed accuracy. Another method of creating indexes began by numbering the actual source document and then microfilming the document by conventional means. The film was then run through the reader with the operator keying, on-line to the computer, the exact frame number for the particular document. This index is then merged with a previous index of subject terms, etc., for the source documents to create a complete computer index leading to exact cassette and frame numbers.

The use of time-shared computer-generated and searchable indexes to microfilm collections is a significant development and boost for the use of microfilm as a medium for information storage and retrieval systems. The DSI microsearch 400 System was one of the first of these systems to be marketed, but will not be the last. The 3M Company plans to market their system with its own "dedicated" minicomputer tied to their Page Search 400 reader/printer. With this type interest being shown by the microfilm industry, new developments and systems should be even more promising.

4.4 Technical Note No. 4

Application of Ultrafiche to the EDS&R Project

While ultrafiche (very high reduction ratio microfiche) has been produced by several companies on a commercial basis for some time, the actual number of applications has been relatively small. With a usual reduction ratio of 150:1 (as compared with 20:1, COSATI Standard, and 24:1, NMA Standard for microfiche reduction ratios) a producer is able to pack literally thousands of pages of information on a single 4" x 6" sheet of microfiche. National Cash Register Co. is the originator of the

ultrafiche, using the Photochromic Micro-Image (PCMI) system, and they have been the most successful producer of ultrafiche applications to date.

Two large applications, that illustrate the advantages and usefulness of ultrafiche, have been designed by NCR for the extensive parts catalogs of the Ford Motor Company and Sears, Roebuck and Company. Ford had formerly been using hard-copy catalogs, but, using ultrafiche, the catalogs for all Ford divisions were reduced to just 6 sheets of PCMI. Sears had been using a cartridge microfilm system when they switched to PCMI and now have over 3,700 PCMI catalog sets and readers in use.

PCMI ultrafiche is produced originally from 35mm microfilm, which is further reduced (using a very sophisticated step-and-repeat camera) by whatever reduction ratio is required, using 150:1 normally, but can be as high as 250:1. Ultrafiche can be indexed by either a conventional hard-copy index or, as in the case of the Ford Parts index, there is enough room on the actual fiche (and there are so few individual fiche) that each 4" x 6" fiche is indexed internally.

The cost of producing each Master PCMI sheet can cost $850 or more, depending upon the number of images transferred, and the step-and-repeat camera that can handle the high reduction ratios cost considerable more than $28,000.00 for conventional model. Add to this the increased cost of ultrafiche readers (approximately 1/3 higher than conventional microfiche reader) and a possible explanation for its limited use will be evident. Recent announcements by the publishers of the Encyclopedia Britannica, however, point out the future for ultrafiche. The company plans to market a series of 20,000 books on 3" x 5" ultrafiche fiche for libraries. While the 3" x 5" format is not at all within anybody's standards, the promotional benefits of the program could well prove beneficial to entire microfilm industry.

Visits were made by DfS personnel to the NCR facility in Bethesda, Maryland. Fiche developed for the Ford catalog application were inspected, and actual use was made of the system. The comments and evaluation, however, were based upon the present philosophy of the EDS&R Project of selected redistribution of engineering data rather than the large scale micro-publishing best suited for existing ultrafiche technology.

4.5 Technical Note No. 5

Review of the Precision Instrument Unicon Laser Mass Memory System

The Unicon (unidensity coherent light data processing system) designed and marketed by Precision Instruments of Palo Alto, California is the

first operational storage and retrieval device capable of maintaining over one trillion bits of binary information on-line to a computer system. The system can be made compatible with any computer system; however, only the larger systems can effectively accommodate the high data transfer rates capable with the Unicon system (4 megabits per second). The purchase price of the Unicon system for approximately one million dollars is quite high, however this breaks down to $.000001 per bit. This is by far the cheapest storage available for computer data.

The Unicon system records data by etching "holes" with a laser beam into the metalic coating on Mylar tape "data strips". Data is retrieved by scanning these strips, again with the laser, but with a different intensity beam. The etched holes tend to transmit rather than reflect light. Each data strip stores almost three billion bits and can be purchased for about $40. The standard system package utilizes 400 such strips on line. The on-line system configuration consists of two rotating drums and a large cylinderical file for the 400 data strips. Each drum may contain only data strip for actual operations. The on-line storage capacity of one trillion bits may be supplemented by any number of data strips stored off-line from the computer system. When searching operations are initiated, each of the drums can retrieve and search any one of the 400 data strips in the file. Overall system search speed may be increased by staggering the drum operations; that is, one drum will be searching an individual data strip while the other drum system is retrieving another strip from the cylinderical strip file. An integrated minicomputer controls all searching and data transfer operations for the Unicon system.

A major significance of the Unicon system to the EDS&R Project lies in its unique ability to maintain massive volumes of data on-line to a computer system at a very low cost per data bit. The drawbacks in this system are its initial cost (about one million dollars) and like microfilm, the fact that the data strips are not erasable. When the data to be stored is entirely alphanumeric, the data strips provide two to three times more storage per dollar than densely packed 16mm cartridge microfilm. The system is capable of storing the equivalent of about 7,000 of these densely packed cartridges on-line, or about 21,000 Miracode cartridges indexed to an average depth of seven columns, and each data item would be accessible from a CRT display or some other console in less than 8 seconds. Microfilm, however, is more economical for storing graphic data. The Unicon system can be economically applied only where tremendous volumes of machineable data require frequent searching. When interfaced with other advanced information handling techniques, the Unicon system could be used within the EDS&R Project to establish a tremendously powerful scientific and engineering data retrieval system.

The information for this technical note came both from the manufacturer's published material and from personal conversations with manufacturer's representatives. The Washington sales manager made presentation on the Precision Instruments system, and he was most cooperative in answering all of our questions.

In the original technical note we pointed out that probably the major drawback to the Unicon system was the high (1 million dollar) initial purchase price for the 1 trillion bit configuration. It is interesting to note that since the technical note was released, Precision Instruments has developed and will market a 10 billion bit storage system called the 6314. This is completely compatible with the IBM 360 line, and has the storage capacity of six 2314 disc packs. This configuration sells for $360,000, or about one-quarter of the price of six 2314 disc packs, and should find relatively wide usage in many larger computer installations. If so, it may become the first commercially successful optical computer memory device. Many computer experts today believe that optical memories will be the major memory system of the future. The resultant lower cost for data storage will have tremendous impact upon the data processing industry in general.

For EDS&R technology, it represents a large scale low-cost storage capability for handling complex indexes in time-sharing type configurations. Conventional microfilm, using odometer or frame count type locating, when coupled to computer index searching to provide frame locations, is a powerful storage and retrieval means for engineering type applications.

4.6 Technical Note No. 6

An Investigation of AMACUS and Its Applications to the EDS&R Project

AMACUS is the acronym for the Automated Microfilm Aperture Card Updating System. The function of AMACUS is to revise information stored on microfilm aperture cards, without generating, modifying and refilming the hard-copy representation. AMACUS was developed as a sub-unit to the U. S. Army Weapons Systems Command (WECOM) Technical Data Package Automated System (TEDPAS). The overall purpose of the TEDPAS Project is to develop a total information system which will store, retrieve, up-date, and reproduce 35mm aperture cards comprising the Technical Data Package/Configuration Management Documents for U.S. Army Weapons Systems Command mission items.

Either graphic or alphanumeric data on aperture cards may be updated. Cards to be revised are optically scanned, digitized, and displayed on a large CRT console. The operator may then revise the displayed drawing using a light pen and alphanumeric keyboard. When revision is complete, a new aperture card is generated for the modified information. AMACUS was built by The Singer Company, Advanced Technology Division. The system is currently operational and is managed by the Management Science and Data Systems Office, Rock Island Arsenal, Illinois.

The major advantages cited for the AMACUS System are increased speed in document revision and elimination of the need for hardcopy files. To operate the system, the operator inserts the aperture card to be revised into the machine; the card is scanned by a CRT and the resultant digitized information is stored on a memory drum in about 90 seconds. When revision is complete, a new aperture card is generated as output, also using CRT. Changes involving largely alphanumeric data require about five minutes of processing time from card input to output; graphic changes are much slower, with processing times ranging between 10 and 25 minutes.

The present AMACUS system has two major disadvantages; purchase price is very high (about $550,000), and the quality of the revised aperture card is degraded with every generation, or revision. There is no ready method for restoring original drawing quality.

Several possible future configurations of AMACUS systems are discussed in the technical note. All of these systems incorporate a laser for scanning and creating new aperture cards rather than the current CRT. This will give a higher resolution, however, the purchase price of future systems will be approximately twice the price of the current system. The high initial purchase price of the system results in what we believe to be a very high unit cost per drawing revision. Thus, we believe AMACUS is currently too expensive for use in the short range EDS&R Project but should be considered, with technological developments, for future EDS&R applications.

4.7 Technical Notes Nos. 7 and 8

COM and Its Applications To The EDS&R Project

Technical Note No. 8 is a ten page summary of Technical Note No. 7; with the exception of one chart summarizing much of the original data presented in Technical Note No. 7, there is no new material included

in Technical Note No. 8. Thus, we have combined the discussion of the two. The purpose of the original Computer Output Microfilm study, Technical Note No. 7, was to investigate and technically review the use of computer output microfilm (COM) techniques in handling engineering data problems relative to the EDS&R Project, and to recommend the necessary interfaces with other areas in EDS&R. Specifically, the study attempted to accomplish the following five goals:

1. Determine the major manufacturers of COM equipment, survey the equipment, including those in operation, available software, and tape authorities.

2. Determine the typical service bureau availability of COM equipment and services, determine the pricing structures, special services offered, and data feedbacks required for processing.

3. Study the total data requirements for COM techniques including the problems involved with interchanging COM equipment from different manufacturers, methods and problems of generating MIRACODE on COM equipment, and conversion problems encountered in using existing binary and BCD tapes.

4. Compare COM techniques, problems, and expenses to other techniques for creating binary coded microfilm.

5. Identify the methods and techniques required to use COM techniques within existing EDS&R applications.

Time considerations on this report did not permit an analysis of all manufacturers of COM equipment. Therefore, we chose the products of seven significant manufacturers for a detailed analysis. Reasons for choosing these seven are discussed in the contents of the technical note. The systems selected for analysis are: Eastman Kodak's KOM-90 Microfilmer, the 3M Electron Beam Recorder, Stromberg Datagraphix Micromation Printer, the RCA Videocomp System, the Datacom 600 System, the Singer/Link APD 5000, and Burroughs Systems. Sales representatives from all of these companies were contacted, and detailed discussions were held with their technical people. Much of our information on COM equipment and the industry in general came from these conversations. We also contacted numerous service bureau organizations in the Washington, D.C. and New York area to learn of their origin, services and pricing structures. At the time of this report, very little published information was available on computer output microfilm techniques. Our findings and recommendations are presented in the report summary below.

Computer output microfilm (COM) recorders are devices which convert data stored on magnetic tape to microfilm by recording the tape data on the face of a cathode ray tube and exposing the film with this image. COM techniques were developed to provide a high-speed computer output in man-usable format. COM recorders are 10-20 times faster than mechanical printers, and microfilm reproduction costs are much lower than paper reproduction costs. The speed and economy of COM recording and reproducing means that users can be given more information with less time lag between generation and distribution.

COM units fall generally into three classes:

1. Business Recorders - record alphanumeric data on 16mm microfilm.

2. Scientific Plotters - plot graphics data on 35mm microfilm.

3. Graphic Arts Recorders - provide high quality output for offset reproduction.

A specific machine may fall into more than one class, and numerous options are available for all equipment.

COM systems, as defined for this report, include the input device (magnetic tape unit or on-line interface), control logic, recording unit, and standard software. Seven specific COM systems were chosen to illustrate characteristics significant to potential users, and each system is discussed in detail with respect to input requirement, output media and microforms, and performance characteristics.

The potential COM user must assure that his data tapes are compatible with the COM unit to be used in a given application. Many COM units can accept tapes prepared for computer line printers; however, if retrieval codes are to be used the tape must be formatted specifically for COM recording. Tapes formatted for COM recording are generally not interchangeable between different producers.

The most common retrieval method used on COM output is some form of image count. The necessary indexes can be generated while the tape data is being produced or formatted for COM recording. Miracode can be produced by several business recorders, but it greatly reduces recorder throughput. COM generated Miracode film differs from ordinary film in that the first generation document image is positive (the CRT image is negative), while the code bits are negative. Miracode produced on Kodak's KOM-90 may have the code columns following the document they identify rather than preceeding it. This requires a permanent modification to the readers for correct retrievals.

All methods for generating Miracode microfilm are discussed in detail. Miracode can be generated by a)manual filming with planetary camera, b) filming on 35mm, mounting on aperture cards, then converting to Miracode, or c) COM recording. Planetary filming is most economical for small documents already in formats acceptable for filming. Documents larger than 11" x 22" must be filmed on 35mm and converted if the entire image is to appear on one 16mm frame. COM is the most economical means for converting magnetic tape data to Miracoded microfilm. Many service bureaus offer COM recorder time based on a per frame charge varying from $.10 - $.015 per frame. Some of these service centers offer programming and other systems assistance, many require the user to program and format his own records and only provide the hardware.

The most immediate advantage of COM to the EDS&R Project will be in converting existing alphanumeric data bases on tape to microfilm. The field of manipulating and generating graphics information is still in its infancy; both hardware and software improvements must develop before such techniques are economically practical.

We recommend further work to locate magnetic tape data sources of interest to EDS&R, and a trial COM application to give EDS&R personnel practical experience in generating and using converted data.

4.8 Technical Note No. 9

Department of Defense Standardization Program; Engineering Data Systems

This technical note was circulated in draft form and never formally issued. We were unable to collect sufficient information concerning the various sub-elements of the EDS program, nor were we able to bring information we had up to date. Information gathered was formatted and presented as the draft note.

The Department of Defense Engineering Data Systems (EDS) is a standardization program for systems, techniques and projects concerned with a "unified and systematic method for the rapid handling of data needed by the design and engineering function". EDS projects have spanned many areas. The EDS, rather than being a single project or program, is in reality a number of independent efforts coordinated as the Department of Defense's Engineering Data System. These various efforts have been numbered as EDS projects, and of these, the EDS0009, developed by the Army Missile Command at Huntsville, Alabama, is probably the best known. Other projects have been completed, some have been dropped, and some are continuing.

The Department of Defense EDS program, originated in August of 1960, has included a total of 63 projects, of which a dozen or so are currently active. The history and general development of the program is discussed in the note followed by descriptions of the major EDS projects.

The purpose of the technical note was to identify and describe these various EDS projects. Distribution of the note via the Defense Documentation Center and the Federal Clearinghouse for Scientific and Technical Information would have made the results of the EDS program to the research and development community. For example, of particular interest to the research and development community are those projects developing holography storage and retrieval equipment, and those applying laser technology to engineering data handling. The EDS0009 Program of coded microfilm for the searching of design items continues to be significant for R&D engineers.

As noted, the effort was severely hampered by lack of information. The meeting notes through the year of 1965 were made available, however, detailed information, or even generalized information, beyond that time was not generally available. For example, we were unable to compile a single consolidated list of all the projects to date authorized under the EDS format. A search was made of the Defense Documentation Center for all reports related to the EDS program. Visits and telephone calls were made with the Department of Defense Technical and Data Standardization Policy Office, The AMC Headquarters Office, and the Standardization activities of the Army Missile Command in Huntsville, Alabama. Distinct efforts were made to track down all leads concerning the various projects identified. These efforts were summarized in a data sheet for each project, showing the EDS number, its name, starting date, assignee, last report date, description and status, reports issued, and the current person to contact concerning the effort. Only the earlier projects through 0009 are sufficiently documented in the technical note.

The effort was not carried to completion because of insufficient information made available. Accordingly, no distribution was made to the Defense Documentation Center.

4.9 Technical Note No. 10

Facsimile Equipment

The objective of this technical note was to determine commercially available facsimile equipment for transmitting over 3 kilocycle telephone lines. The technical note consists of equipment description sheets arranged by manufacturer giving pertinent performance, availability, and pricing data for each "off-the-shelf" type equipment or system. In total, about 30 systems are represented.

The following information is given for each system:

1. Manufacturer's name and address
2. The model number and system name
3. Lines used--either direct dial or dedicated, and the degree of conditioning
4. Purchase price
5. Monthly rentals
6. The type of printing used for output
7. The resolution
8. The input and output paper sizes
9. Line coupler (an effort of inputting the facsimile scanners output to the transmission line)
10. Available options with the system

Several directories were used to determine all manufacturers of commercially available facsimile equipments. All manufacturers were contacted by mail and requested to send all pertinent specifications and literature for their product lines. Once this literature had been studied and summarized, the manufacturers were again contacted, this time by telephone, and requested to answer any remaining questions. Information was then transferred to the equipment description sheets. The contractor also attended several demonstrations of facsimile equipment in the Washington area. The following manufacturers of facsimile equipment are represented in the technical note:

1. Alden Electronic and Impulse Recording Equipment Company, Inc.
2. Convacs Communication Corporation
3. Dictaphone Corporation
4. Electronic Image Systems, Inc.
5. Electronic Transmission Systems, Inc.
6. Graphic Sciences, Inc.
7. Graphic Transmission Systems, Inc.
8. International Scanatron Systems Corporation

9. Litton Industries

10. Magnavox Systems, Inc.

11. Muirhead Inc.

12. Stuart Warner Corporation

13. Telautograph Corporation

14. Western Union

15. Xerox

Additional research was conducted in this area to identify techniques used to compress data in conjunction with facsimile transmission. Current periodical and journal indexing services, Clearinghouse reports, Defense Documentation Center, and other sources were queried. While a great deal of information is available in regard to coding techniques for data and digital compression both before, and during transmission, little relates to the facsimile field. Insufficient information was located on the subject to form a basis for a technical report.

4.10 Technical Note No. 11

The GESCAN Information Storage and Retrieval System

This technical note was requested by the Contract Project Officer, and investigates a unique and interesting new product for information retrieval. The new device is produced by General Electric Corporation and is called the General Electric Rapid Search Machine, or GESCAN System. GESCAN is unique because it is the only commercially available system today designed and dedicated solely to rapidly searching and retrieving data from magnetic tape files. The device incorporates a parallel or associative processor to perform the rapid search. This parallel processor can compare up to 80 characters of magnetic tape simultaneously to an 80 character search query, rather than a character at a time as with a general purpose serial digital computer. Using GESCAN, the full text of documents stored on magnetic tape may be searched very rapidly; in fact, the full text may often be searched faster than searching a directory of index terms and locating documents with controlled vocabulary on a general purpose computer. Thus, for certain types of documents, an added benefit of the GESCAN System may be the elimination of the initial indexing step in document storage.

The GESCAN System is physically divided into three self-contained subsystems: The input-output control console, the associative processer, and the input magnetic tape drives. The input/output control console consists of a cathode ray tube (CRT) display, a fast, quiet, electrostatic printer, and a control keyboard. All search queries and control functions are performed at this console.

The magnetic tape transports provided by General Electric with the GESCAN system are manufactured by Potter Instrument Company; however, tape units from other manufacturers could probably be interfaced with little or no trouble. Tapes used are standard ½" in width recorded at a density of 800 BPI. The tape unit transfers data from the associative processer at a rate of 150" per second, or 120,000 characters per second. The associative processer contains all logic and performs the searching operations. The full 2400 foot reel of magnetic tape contains over 23 million characters and may be searched completely in approximately 3-4 minutes. There are very few restrictions placed on the tape record format for the GESCAN system: tapes may be prepared on any digital computer system or directly keyed for GESCAN operations. The GESCAN system sells for $189,500 or may be leased from a third party with a maintenance contract for about $5000 per month. The major advantage of the GESCAN system is that it can search and retrieve information from large randomly arranged magnetic tape data bases faster and more economically than most any other system. The major disadvantage of GESCAN is that it does not have the capability for performing numeric searches of any kind other than direct equality. One cannot search for numeric ranges, or for the value of some parameter "greater than" or "less than" the value of the search query.

Possible future GESCAN systems are far more interesting than the present configuration. As is, the GESCAN system is compatible with the computer environment; however, in the future a GESCAN system may be modified to act essentially as a standard peripheral device. Thus, the general purpose processor would perform all numeric searches and data manipulation, the GESCAN would be used for file searching. Other possible GESCAN configurations are discussed in the text of the technical note.

In summary, the GESCAN system is not designed to retrieve the type of numeric component data normally required by the "workbench" engineer. The system would be particularly useful in a large scientific or technical information center, either to search full text on the original journal articles or to search the abstracts of these articles. The most significant aspect of the GESCAN system to the EDS&R Project may simply be the concept that an associative processer which has the capabilities of searching large files very rapidly is now commercially available. General Electric

currently plans to interface the GESCAN system with disc packs, minicomputers, and remote processing devices. These future developments should be watched for their impact on the field of information retrieval.

The information for this technical note was derived from the technical literature published by General Electric Company and from personal contact with the marketing and technical people responsible for product applications. The contractor attended a demonstration of the GESCAN system given in Washington, D. C. in the summer of 1970, and was quite impressed by the retrieval capabilities of the machine.

4.11 Technical Note No. 12

Conversion of Existing Index Structures to Binary Code Microfilm

An analysis was made of various file structures, file arrangements, indexing methods, and vocabulary structures, to determine the methods and techniques which could be used to convert existing files and collections of information to binary coded microfilm (BCM). It was realized that these factors presented major problems in actually converting existing files to the EDS&R storage and retrieval media.

File arrangements present the greatest initial problem. If the material cannot be logically grouped, conversion to BCM is somewhat impractical. File arrangements which group the document images, such as subject filing or hierarchical arrangements, are discussed, noting their features relative to BCM conversion.

Index structures, likewise, present problems for conversion to BCM if the indexing terms are not directly associated with the material to be microfilmed or with the aperture card image. Files with associated indexes are converted without major manipulation, but usually additional indexing is required to give the depth search capability which makes BCM practical. Files with independent indexes, on the other hand, require major data manipulation to incorporate the index information back with the respective material.

The standard methods of generating BCM give some flexibility for converting the larger and more complex files, and computer techniques of sorting, reformating, and generating BCM numeric indexing are discussed.

Specific solutions for handling complex vocabularies by calculated false retrievals, structured vocabularies by cartridge groups, and generation of a master search index for total file search, are developed.

Conclusions are that existing files with materials logically grouped by subject matter, descriptive attributes expressed in numbers or ranges, and with existing indexes capable of association with the material, are best suited for binary coded microfilm conversion.

5.0 Summary, Conclusion and Recommendations

5.1 Summary

The Dataflow Systems' activities have provided selected screening and analysis functions for the EDS&R project. Our vista of information technology has been broad, and many diverse activities have been sampled and noted. Under the direction of the Contract Project Officer, selected areas have been analyzed to give insight and prospective views relative to the EDS&R goals. Through this means, the paths to the goals may be modified or selected, and even the goals themselves evaluated in face of changing technology and needs.

The preceeding technical notes have presented and analyzed various techniques. The Master Index has become a specific embodiment of the EDS&P philosophy of maximum reuse of data and information through exchange programs. The EDS&R Monthly Review has brought items of interest, with appropriate comment, to the attention of many associated with the EDS&R Project. These items were sometimes peripheral to engineering data, but the trends and progress they represent are significant to the EDS&R effort.

In total, the Data Survey and Analysis effort have served as a communication link between the world of information technology and the EDS&R Project. It has both gathered and distributed information. In doing so, it has helped make the information community aware of the EDS&R concept, and the EDS&R management aware of the changing technology and important trends. This awareness is vital to the philosophy noted in section 2.1.

5.2 Conclusions

If any single item can be concluded from our efforts, it must be that the EDS&R Project is and will be influenced by changes in the field of information technology. Within this field, we see the greatest

potential impact from areas which couple the logical search capability of the computer with the graphic storage capability of microfilm.

Of particular note is the potential of the mini-computer to become an economic part of on-site storage and retrieval systems, and the coupling of video techniques with both microfilm and computer technology to provide the "erasable media" aspects.

In the microfilm area, 16mm cartridge based systems will continue to grow, particularly in the technical information areas. Binary coded microfilm, as it is presently constituted, does not appear to be a widely accepted media, but new advances expected in the field could have major impact in the future. 16mm image-count type systems are becoming popular, but we do not see a large growth in this area vs. conventional 16mm systems. We see, however, major commercial effort in all areas of 16mm microfilm systems, and more and more this is becoming the wave of the future.

The rapid growth of the number of computer-output-microfilm manufacturers indicates a sound technology and a large projected market for the devices. As noted in our Technical Note 7, possibly the greatest significance of COM to the EDS&R Project is the coupling of systems and computer personnel to the technology of microfilm. The many marriages may not be always successful, but the spawning of new advances in information technology is sure to result. COM applications already are making computer data economically available where before the simple cost of printing a data base has kept valuable data in an unreadable format. Future production of sophisticated data listings and indexes, possibly coupled to binary coding, will have continued impact in the EDS&R Project.

Communications technology and economics of communicating may likewise cause major re-evaluations of EDS&R system configurations. The increased use of facsimile equipment will make any remote location servicable from a central storage and retrieval point. Other EDS&R Project activities are active in this area. Our initial analysis indicates that such arrangements are economically feasible for small user groups when compared to normal alternatives.

Engineering data exchange, as a concept, appeals to many, but our survey activities have indicated little support from the originators or holders of files. Generally speaking, their missions do not include distribution of their collected data and information, and many collections are not particularly packaged with instructions, indexes, and necessary guides required for the uninitiated to use the collections.

Both private and government sectors have shown a reluctance to release information for unrestricted government use. There appears to be an unspoken fear that the information may be improperly used or used in some way not to their benefit. This is not a new problem, but it can be reduced by a better understanding of the EDS&R goals by the contributor. The activities of this contract have greatly assisted in this understanding.

5.3 Recommendations

Our conclusions have noted the evolving technical developments that have great potential in solving some of the basic problems of engineering data storage and retrieval. The major attention of the recommendations that follow are based upon exploring, testing and evaluating these developments.

1. The EDS&R Project should continue and increase its active participation in engineering areas related to data storage and retrieval. Greater emphasis should be placed upon noting, describing, and evaluating existing and new applications of data storage and retrieval techniques.

a. A series of "EDS&R Application Notes", including appropriate evaluations, should be issued by the Project. These notes prepared by originators, sponsors, or developers of these applications, or by the Project itself, could cover either equipments, systems or specific problem areas in engineering data storage and retrieval.

b. Commercial producers of equipments of potential use in the EDS&R area should be encouraged to prepare similar notes.

c. A summary of existing engineering data programs and activities within the Department of Defense should be made and published.

2. Specific applications for EDS&R evaluation should be encouraged, and the EDS&R Project should provide the leadership in bringing technology to bear on existing EDS&R requirements.

a. The EDS&R requirements, and specific description of problems, should be gathered and publicized to the information technology community in the form of a seminar and appropriate written material.

b. The engineering managers should be made more aware of the potential solutions available for their problems. The better solutions should be presented to them, and applications encouraged and, if necessary, in part supported by the EDS&R Project.

c. In particular, applications using data processing techniques in active conjunction with microfilm should be given great attention because of their potential.

3. We recommend expansion and encouragement of all activities that tend to communicate the goals and accomplishments of the EDS&R Project to the engineering community, whether government or private.

a. Appropriate reports, summaries, or other material of a technical nature should be announced and made available through the Defense Documentation Center.

b. The trade literature related to the EDS&R area should be actively encouraged and used to communicate to the engineering community, via contributed articles, interviews, and press releases.

c. Seminars and presentations of EDS&R technology, applications and problem areas should be considered as potential means of communicating to both the users and producers of EDS&R technology.

d. The "EDS&R Technical Notes from the Current Literature" should be continued with expanded distribution.

4. The Master Index to Engineering Data Collections in 16mm should be updated, and any exchange of engineering data noted.

5. Additional analysis, development, and description should be made of various systems configurations which can serve data and information needs via combinations of centralized or decentralized indexing and centralized or decentralized document storage. In particular, centralized index searching from a remote location coupled with facsimile transmission configurations should be investigated and evaluated.

6. The EDS&R Project should develop evaluation procedures for various engineering data systems so that economic trade-offs may be meaningful. We recommend that basic units of measurement, such as cost per search or cost per record stored, be specified, and procedures for making these measurements developed.

7. Microfiche is a well accepted microfilm media for DOD technical reports while aperture cards are widely used for storing and retrieving engineering data and drawings. We recommend that applications concerning improved methods, techniques and equipment for microfiche and aperture card storage and retrievel be supported and documented by the EDS&R Project, and used for making EDS&R Project comparisons. We recommend that the EDS&R Project reduce development of binary coded microfilm systems based upon existing commercial equipments, and investigate similar applications using other techniques. The present equipment and configurations are well tested and known, while the potential of alternative applications and techniques could be considered in greater depth.

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13 ABSTRACT

The Data Survey and Analysis task, under the Engineering Data Storage and Retrieval (EDS&R) Project, screens, selects, gathers, analyzes and develops information related to the storage and retrieval of engineering data. These activities, directed toward defining current, new and future systems of engineering data storage and retrieval, have produced a series of publications and reports, including a Master Index to Engineering Data Files in 16mm Microfilm Format, a monthly engineering data systems review, and a series of twelve technical notes covering specific investigations of equipments (AMACUS, GESCAN, UNICON, DSI 400), of techniques (converting file structures to binary coded microfilm), of programs (the DOD Engineering Data System), and of definitions and scope of the EDS&R Project. Conclusions and recommendations are presented.

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Microfilm Storage and Retrieval Systems						
Data Exchange Programs						
COM (Computer Output Microfilm)						
Facsimile Transmission Equipment						